WHAT IS CLAIMED IS:

1. A compact fuel processor for converting a hydrocarbon fuel feed to hydrogen rich gas, comprising:

a cylinder having an inlet end and an outlet end, wherein the cylinder is loaded with a plurality of catalysts in series fashion thus forming a series of reaction zones; and

a heat exchanger having an inlet end and an outlet end, wherein the heat exchanger is internally positioned through the length of the cylinder so as to provide heat or remove heat as required by a particular reaction zone.

2. The compact fuel processor of claim 1, wherein the plurality of catalysts comprises autothermal reforming catalyst, desulfurization catalyst, water gas shift catalyst, and preferential oxidation catalyst.

3. The compact fuel processor of claim 2, wherein the heat exchanger is not positioned within the autothermal reforming catalyst.

4. The compact fuel processor of claim 2, wherein the hydrocarbon fuel feed is preheated by passing through the heat exchanger prior to being introduced to the cylinder.

5. The compact fuel processor of claim 2, wherein the hydrocarbon is selected from the group consisting of natural gas, gasoline, diesel, fuel oil, propane, liquefied petroleum, methanol, ethanol, and mixtures of these.

6. The compact fuel processor of claim 1, wherein the inlet end of the heat exchanger is at the outlet end of the cylinder.

7. The compact fuel processor of claim 1, wherein the cylinder is oriented substantially vertically with the outlet end of the cylinder being on top.

8. A compact fuel processor for converting a hydrocarbon fuel feed to hydrogen rich gas, comprising:

a reaction chamber

a plurality of predefined reaction zones within said reaction chamber, wherein each reaction zone is characterized by the chemical reaction that takes place within the reaction zone.; and

a heat exchanger having an inlet end and an outlet end, wherein the heat exchanger is positioned within the reaction chamber.

9. The compact fuel processor of claim 8, wherein a first reaction zone contains autothermal reforming catalyst, a second reaction zone contains desulfurization catalyst, a third reaction zone contains water gas shift catalyst, and a reaction zone module contains preferential oxidation catalyst.

10. The compact fuel processor of claim 9, wherein the heat exchanger is not positioned within the first reaction zone.

11. The compact fuel processor of claim 8, wherein the hydrocarbon fuel feed is preheated by passing through the heat exchanger prior to being introduced to the reaction chamber.

12. The compact fuel processor of claim 8, wherein a mixture of hydrocarbon fuel feed, air, and water is preheated by passing through the heat exchanger prior to being introduced to the first reaction zone.

13. The compact fuel processor of claim 9, wherein the inlet end of the heat exchanger is at the fourth reaction zone and the outlet end is at the second reaction zone.

14. The compact fuel processor of claim 8, wherein each reaction zone of the plurality of reaction zones may contain one or more catalysts selected from the group consisting of autothermal reforming catalyst, desulfurization catalyst, water gas shift catalyst, and preferential oxidation catalyst.

15. The compact fuel processor of claim 14, wherein a reaction zone containing more than one catalyst is separated from an adjacent reaction zone and is supported by a permeable plate.

16. The compact fuel processor of claim 15, wherein the plate is selected from the group consisting of perforated metal, metal screen, metal mesh, sintered metal and porous ceramic.

17. The compact fuel processor of claim 16, wherein the plate is of a material selected from the group consisting of inconel, carbon steel, and stainless steel.